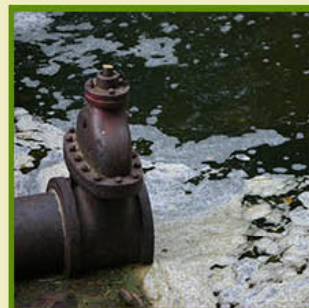


Pollution Prevention: Region 5 Hazardous Substance Reduction On the Path to Greener Chemistry

Module 1: Pollution Prevention and Hazardous Substance Reduction Fundamentals



P2: On the Path to Greener Chemistry



MODULE INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has developed a 160-slide, four-part training module series (approximately 5 hours for the self-guided module series) that provides an introduction to Pollution Prevention (P2) fundamentals related to hazardous substances reductions, through the lens of green chemistry concepts (Module 1 of 4). This module is the result of collaboration among EPA headquarters and EPA Region 5; input from other EPA Regions is underway, and will be used to inform updated modules. This document provides key information on using this module.

This module can be used as a stand-alone training or in conjunction with EPA's other related training modules to provide a more in-depth training for P2 staff and P2 Technical Assistance Providers (TAPs) on hazardous substance reductions. The goal of this module, and the overall training series, is to inform P2 staff and P2 TAPs of proven approaches, strategies and tools that can be used to achieve increased hazardous substance reductions. To achieve this goal, EPA will increase the awareness of existing tools and approaches so they can successfully be integrated into organizational P2 assessment protocols. Each of the modules includes specific goals that will support the overall training goal and desired outcomes.

The material in this presentation should not be quoted or cited as official EPA policy. Additionally, the tools identified in this presentation are not an endorsement of, or intended to be an endorsement of any particular tool, unless it was developed by EPA.

INTENDED USERS AND TARGET AUDIENCE

This module is intended for use by P2 TAPs and State P2 staff who want to better understand hazardous substance reduction fundamentals through green chemistry and green engineering concepts.

TRAINING MODULE OBJECTIVES:

- Articulate how the P2 definition has evolved over time
- Articulate the differences between Green Chemistry, and Green Engineering
- Increase use of EPA's P2 calculator to calculate green house gas reductions related to certain chemical substitutions

P2: On the Path to Greener Chemistry



The module begins by reviewing EPA's definition of Pollution Prevention and its evolving scope over time. The module then addresses the definition of green chemistry and green engineering and their roles in hazardous reductions. The module then touches on the four National Pollution Prevention metrics (pounds of hazardous substances reduced, metric tons of CO₂, gallons of water conserved, and dollars saved by facilities) used to quantify results of implemented P2 activities. The module wraps up with a brief reference to EPA's P2 Calculators which support calculating P2 metrics, as well as tips for using the calculator to capture green house gas reductions that may result when reducing certain hazardous substances.

HOW TO USE THIS MODULE

This module is available as a PowerPoint presentation with slides. The recommended timeframe is approximately 1 hour for the presentation. EPA may update and adapt the training module to reflect region-specific and state-specific issues and concerns, as well as incorporate new policy and legal considerations as they arise.

ADDITIONAL RESOURCES

USEPA (U.S. Environmental Protection Agency). 1990. Pollution Prevention Act
<http://www2.epa.gov/laws-regulations/summary-pollution-prevention-act>

USEPA (U.S. Environmental Protection Agency). Measuring Pollution Prevention: P2 Calculators
<http://www.epa.gov/p2/pubs/resources/measurement.html>

*Additional resources specific to Module 1 are located in Appendix A of this Module.

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MODULE AT A GLANCE

Duration and <i>Elapsed Time</i>	Module 1 Topics	Pages
10 minutes <i>10 minutes</i>	Purpose of the training	6–8
15 minutes <i>25 minutes</i>	Defining P2 and its evolving scope	9–15
20 minutes <i>45 minutes</i>	Defining green chemistry and green engineering	16–27
15 minutes <i>1 hour</i>	National P2 metrics and calculators for measuring success	28–37
TOTAL TIME: 1 HOUR		

P2: On the Path to Greener Chemistry



Icon Key



Instructions

This icon means there are specific instructions for the facilitator. This content should not be read aloud.



Background

This icon indicates that there is background information the facilitator should be aware of when covering this topic. This information is for the facilitator only.



Facilitator Says

This icon means the facilitator should read the content nearly verbatim, interjecting his/her thoughts when appropriate.



Key Point

This icon indicates an important point that the facilitator should communicate to the audience in his/her own words.



Discussion Questions

This icon means the facilitator should allow time for the audience to ask questions or the facilitator should ask the audience questions.



Multimedia

This icon indicates the facilitator will have students watch a video.



Online Resource

This icon indicates the facilitator will have students visit an online resource.



Handouts or Resource Materials

This icon indicates the facilitator will give students a handout or other resource material.



Transition

This icon indicates the facilitator will provide a transition from one topic to another.

P2: On the Path to Greener Chemistry

Pollution Prevention: Region 5 Hazardous Substance Reduction on the Path to Greener Chemistry

U.S. EPA, Region 5
December 9, 2013



Subtopic

Purpose of the training
10 minutes

Specific Outcomes

Notes for the Facilitator



Say: Welcome to the “Pollution Prevention: Region 5 Hazardous Substance Reduction on the Path to Greener Chemistry” training. This is the first module in a series of four. The total time for this training is 5 hours; this module requires approximately one hour.

This EPA-developed training module introduces pollution prevention (P2) fundamentals related to hazardous substance reductions, through the lens of green chemistry concepts. It is the result of collaboration between EPA headquarters and EPA Region 5. Input from other EPA regions is underway, and will be used to inform an updated training.

The goal of this module, and the overall training series, is to inform P2 staff and P2 Technical Assistance Providers (TAPs) of proven approaches, strategies, and tools that can be used during a P2 assessment to achieve increased hazardous substance reductions. To achieve this goal, EPA will increase the awareness of existing tools and approaches so they can successfully be integrated into organizational P2 assessment protocols.

P2: On the Path to Greener Chemistry

Purpose of This Training

- Increase hazardous substance reductions in small and medium businesses in Region 5
 - Best management practices
 - Case studies
 - Tools and resources
 - Disclaimer: The tools and resources identified in this presentation are not an endorsement of any particular tool, unless it was developed by EPA.
 - Targeting strategies



Subtopic

Purpose of the training
10 minutes

Specific Outcomes

Notes for the Facilitator



Say: The purpose of this training is to increase the use of proven approaches and resources that support hazardous substance reductions in Region 5, especially in small and medium businesses. This will be accomplished by identifying BMPs that have been implemented, highlighting examples as identified by case studies, and highlighting tools and resources that can identify safer chemical alternatives to those hazardous substances currently being used by businesses.

Strategies for identifying businesses that may be interested in reducing their hazardous substance usage will be discussed. At the end of this training, we want participants to be familiar with proven approaches and resources that all lead to one common goal, which is reduced use of hazardous substances.

Disclaimer: the tools and resources identified in this presentation are not an endorsement of any particular tool, unless it was developed by EPA.

P2: On the Path to Greener Chemistry



Subtopic

Purpose of the training
10 minutes

Specific Outcomes

Notes for the Facilitator



Say: This training was developed through the lens of the life cycle perspective and green chemistry principles. The use of the life cycle perspective helps us to identify possible environmental improvements across the industrial process. While many of the green chemistry principles are applied to chemicals being formulated during the “manufacturing” phase of the life cycle, this training will primarily focus on hazardous substance reductions and green chemistry principles during the next phase of the life cycle, which is the “use” stage. More specifically, the training focuses on how the business “use” of certain chemicals can be reduced, through adoption of P2 BMPs or safer chemical substitutions.

The use of BMPs supports the first of the 12 Principles of Green Chemistry, which informs us it is better to prevent waste than to treat it or clean it up. The use of safer chemical substitutes supports the fifth principle, which informs us to use safer chemicals whenever possible. Using safer chemicals in businesses or preventing increased usage of certain chemicals in businesses will result in increased hazardous substance reductions. This training will also touch on EPA’s Design for the Environment Assessment approach, informing us of certain criteria used in the design of safer chemicals during the “manufacturing” phase of a chemical’s life cycle. The DfE assessment approach supports the fourth Principle of Green Chemistry, and would also lead to increased hazardous substance reductions.

P2: On the Path to Greener Chemistry

Feedback/Comments

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Subtopic

Purpose of the training
10 minutes

Specific Outcomes

Notes for the Facilitator



Instructions: The host or primary facilitator of the training should insert appropriate contact information on this slide.

P2: On the Path to Greener Chemistry

Fundamental Concepts of P2 and Hazard Reduction



Subtopic

Defining P2 and its evolving scope
15 minutes
(Elapsed time: 25 minutes)

Specific Outcomes

Articulate how the definitions of P2 and source reduction have expanded over time

Notes for the Facilitator



Say: This is the first slide of a series that focuses on topics related to the fundamentals of pollution prevention, source reduction, green chemistry, and green engineering.

Subtopics

- Defining P2 and its evolving scope
- Defining Green Chemistry and Green Engineering
- National P2 Metrics and Calculators for Measuring Success

Specific Outcomes

- Articulate how the P2 definition has expanded over time
- Articulate the difference between Green Chemistry and Green Engineering
- Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

P2: On the Path to Greener Chemistry

Defining Pollution Prevention

The Pollution Prevention Act of 1990 (which authorizes P2 grants) defines P2 as **source reduction**, which:

- Is any practice that reduces a hazardous substance, pollutant, or contaminant (HSPC) entering the environment pre-recycling and thereby reduces hazard
- Includes equipment/technology/process modification, product redesign, material substitution, better house-keeping, maintenance, training, and inventory practices
- Excludes altering HSPC characteristics (physical, chemical, biological, volume) through a process not integral to producing product/service



Subtopic

Defining P2 and its evolving scope
15 minutes
(Elapsed time: 25 minutes)

Specific Outcomes

Articulate how the definitions of P2 and source reduction have expanded over time

Notes for the Facilitator



Say: As stated in the definitions section of the Pollution Prevention Act of 1990, the term “source reduction” means any practice that:

- Reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal.
- Reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.

The term includes equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control.

The term “source reduction” does not include any practice that alters the physical, chemical, or biological characteristics or the volume of a hazardous substance, pollutant, or contaminant through a process or activity that itself is not integral to and necessary for the production of a product or the providing of a service.

P2: On the Path to Greener Chemistry

Defining Pollution Prevention

- EPA 1992 P2 policy statement
 - Clarifies that in-process recycling is P2
 - Defines P2 as source reduction (PPA) plus conserving and using energy, water, and other resources more efficiently
- Executive orders on greening government
 - The first 1993 EO on P2 compliance defined P2 as the EPA 1992 policy statement does; subsequent ones rely on multiple statutes (EO 13148 emphasized source reduction, and others include conservation and efficient use of resources)



Subtopic

Defining P2 and its evolving scope
15 minutes
(Elapsed time: 25 minutes)

Specific Outcomes

Articulate how the definitions of P2 and source reduction have expanded over time

Notes for the Facilitator



Say: Pollution prevention approaches can be applied to all pollution-generating activity, including those found in the energy, agriculture, federal, and consumer sectors as well as industry. The impairment of wetlands, ground water sources, and other critical resources constitutes pollution, and prevention practices may be essential for preserving these resources . . .

In the agricultural sector, pollution prevention approaches include reducing the use of water and chemical inputs; adopting less environmentally harmful pesticides or cultivating crop strains with natural resistance to pests; and protecting sensitive areas. In the energy sector, pollution prevention can reduce environmental damages from extraction, processing, transport, and combustion of fuels. Pollution prevention approaches include increasing efficiency in energy use; substituting environmentally benign fuel sources; and making design changes that reduce the demand for energy.



Background Information: (References)

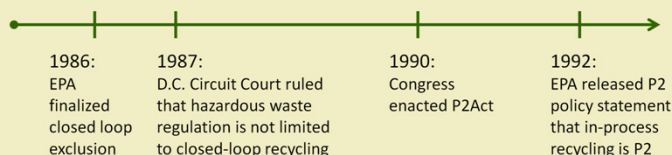
- May 28, 1992, memorandum from Henry Habicht, EPA Deputy Administrator, to all EPA personnel on the EPA definition of “pollution prevention.”
- Executive Order 12856 (1993): Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements (EPCRA and PPA)*
- Executive Order 13101 (1998): Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition (RCRA)*
- Executive Order 13148 (2000): Greening the Government Through Leadership in Environmental Management (EPCRA, PPA, CAA)*
- Executive Order 13423 (2007): Strengthening Federal Environmental, Energy, and Transportation Management (now codified into law)*
- Executive Order 13514 (2009): Federal Leadership in Environmental, Energy, and Economic Performance*

*All EOs rely on all laws; some EOs name specific laws as well.

P2: On the Path to Greener Chemistry

Scope of Source Reduction

Source reduction has a *history of broadening*



Subtopic

Defining P2 and its evolving scope
15 minutes
(Elapsed time: 25 minutes)

Specific Outcomes

Articulate how the definitions of P2 and source reduction have expanded over time

Notes for the Facilitator



Discussion Question: Considering this timeline, do you think RCRA developments may have affected the P2 Act and EPA's 1992 P2 Policy Statement?



Say: The timeline for a broadening definition of source reduction includes:

- 1986—EPA finalized the closed-loop exclusion to the Definition of Solid Waste. Under RCRA, hazardous waste is a subset of solid waste. Excluded material is not waste because it has not been discarded.
- 1987—the D.C. Circuit Court held that exclusion from RCRA hazardous waste regulation is not limited to closed-loop recycling, but extends to in-process recycling. Material that passes from one process to another has not been discarded.
- 1990—Congress enacted the Pollution Prevention Act.
- 1992—EPA noted in its P2 Policy Statement that in-process recycling is P2.



Background Information: A 1992 EPA memorandum clarified the definition of “pollution prevention,” stating that in-process recycling is P2. It also defined P2 as source reduction (PPA) plus conserving and using energy, water, and other resources more efficiently. In the P2 Policy Statement, EPA may have been taking into account the 1987 ruling. The 1987 D.C. Circuit Court ruling stated that “exclusion from hazardous waste regulation is not limited to closed-loop recycling, but extends to secondary materials that pass in a continuous stream from one production process to another to be recycled and reused. EPA need not regulate [under RCRA] ‘spent’ materials that are recycled and reused in an ongoing manufacturing or industrial process. These materials have not yet become part of the waste disposal problem, they have not yet been discarded.” *American Mining Congress v. EPA*, 824 F. 2d 1177, 1186 (D.C. Cir. 1987)

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Source Reduction Assistance: Hazard Assessment

Focus:

- Applies to **products** purchased, used, and made by a facility
 - Products are chemicals, materials, formulations, etc.
- Goal is to reduce hazard by degree or volume
- The value of hazard assessment has been demonstrated by DfE, green chemistry, Region 9 solvent substitution work, etc.
- EPA supports multiple P2 tools for this purpose:
 - Green chemistry (www.epa.gov/greenchemistry)
 - Design for the Environment (www.epa.gov/DfE)
 - Green engineering (www.epa.gov/oppt/greenengineering)
 - Energy, Economy, and Environment Partnership (www.e3.gov)
 - EPA's P2 resources (www.epa.gov/p2/tools/p2tools.htm)



Subtopic

Defining P2 and its evolving scope
15 minutes
(Elapsed time: 25 minutes)

Specific Outcomes

Articulate how the definitions of P2 and source reduction have expanded over time

Notes for the Facilitator



Say: Today's training focuses on reducing the relative hazard of products at a facility. The goal of a hazard assessment is to reduce hazards by a measurable degree. Such hazard assessments are proven valuable by EPA efforts such as Design for the Environment, green chemistry, and Region 9's solvent substitution work.

This slide also lists available P2 tools that help support hazard assessments.

P2: On the Path to Greener Chemistry

Source Reduction Assistance: Hazard Assessment

Context for hazard assessment:

- Assessing and reducing the hazards of chemical products
- At the same time, some hazardous chemicals and materials currently have specific industrial uses and few existing substitutes; they are often “building-block” chemicals (the first yields of refining of oil and gas, obtained whether desired or not)
- Managing the environmental footprint of these materials can include:
 - For spent building-block chemicals and some other hazardous secondary materials, pollution is prevented by reusing and remanufacturing them to extend their commercial “afterlife.” This reduces the pace of their creation and destruction, which are their most environmentally intense aspects. These activities generally relate to remanufacturing and green engineering.



Subtopic

Defining P2 and its evolving scope
15 minutes
(Elapsed time: 25 minutes)

Specific Outcomes

Articulate how the definitions of P2 and source reduction have expanded over time

Notes for the Facilitator



Say: Assessing and reducing the hazards of chemical products are important and effective steps of a hazard assessment. At the same time, some hazardous chemicals and materials currently have specific industrial uses and few existing substitutes. They are often “building-block” chemicals (the first yields of refining of oil and gas, obtained whether desired or not). Building block chemicals are less than a dozen in number, but high in volume.

Chemical and material products amenable to remanufacturing or direct reuse include solvent byproducts, spent solvents, secondary chemical mixtures and compounds, electric arc furnace dust, spent pickle liquor, and secondary materials characteristically toxic for metals and otherwise characteristically toxic, among others.

Sectors generating these products include small and larger chemical manufacturers; pharmaceutical facilities; steel mills; printing operations; secondary smelting; and manufacturers of metal cans, medicinal and botanicals, printing inks, electromedical supplies, machinery, semiconductors, paints and coatings, aluminum sheet, plate, and foil, motor vehicle bodies, metal doors and windows, iron/steel pipes and tubes, plastics and resins, electronic capacitors, circuit boards, and kitchen cabinets and countertops.

P2: On the Path to Greener Chemistry

Source Reduction Assistance: Hazard Assessment

Examples from State P2 Leadership Program results reported to EPA in FY 2011:

- Dupont (VA) reported that it reclaimed toluene for third party reuse to Virginia Environmental Excellence Program
- Pfizer (MI) reported to Michigan Environmental Leadership Program that its pharmaceutical production plant is recovering solvent for reuse on site and for third party reuse



Subtopic

Defining P2 and its evolving scope
15 minutes
(Elapsed time: 25 minutes)

Specific Outcomes

Articulate how the definitions of P2 and source reduction have expanded over time

Notes for the Facilitator



Instructions: This slide provides examples from State P2 Leadership Program results reported to EPA in FY 2011.



Say: Dupont (Virginia)—Following the advice of its hazardous materials contractor, DuPont determined it could exempt its spent toluene under RCRA's Definition of Solid Waste so the toluene could be economically reclaimed to product specifications and reused by a third party. DuPont designed for separating the spent toluene from other materials, had it reclaimed, and sold it for third party use. DuPont reported the volume of toluene it reclaimed for third-party reuse as pollution prevention results to the Virginia Environmental Excellence Program, and Virginia reported these results to EPA under a P2 grant.

Pfizer (MI)—For years, this Pfizer pharmaceutical production plant has been recovering solvent on site for efficient reuse. They renew the solvent through distillation and reuse it on site for their own needs. More recently, this plant sold some solvent it had used once in "as is" condition to a third party for reuse. Pfizer reported this "as is" sales volume as pollution prevention results to the Michigan Environmental Leadership Program, and Michigan reported these results to EPA under a P2 grant.

EPA would like to acknowledge the states that reported these results to EPA's P2 Program.

P2: On the Path to Greener Chemistry

Green Engineering: Extended Material Life

Remanufacturing and principles of extending material life include:

- Design for separation
- Design for commercial “afterlife”
- Renew rather than deplete; maximize efficiency
- Meet need, minimize excess
- Integrate material and energy flows



Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: One aspect of green engineering is extending the commercial life of materials, particularly spent (used) solvents, under appropriate conditions, to have longer commercial life.

Remanufacturing (re-processing) allows the market to slow the pace at which virgin solvents need to be generated and destroyed.

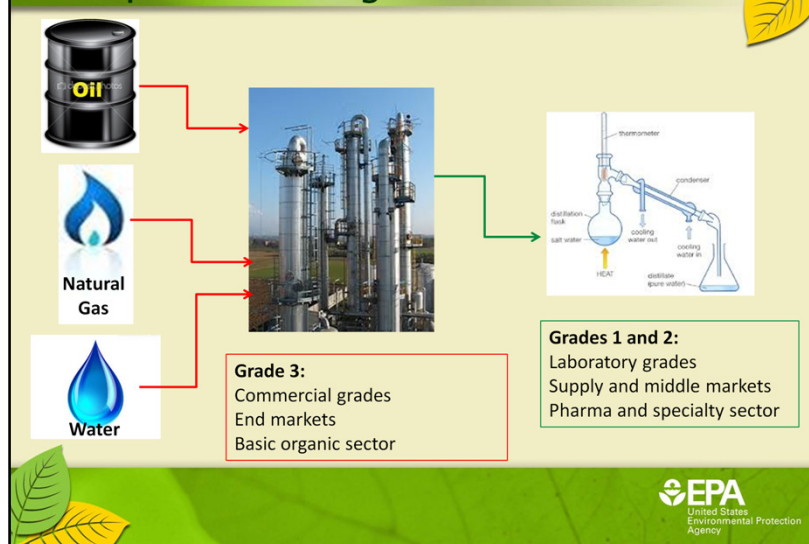
Since the creation and destruction of solvents is environmentally and economically intensive, but remanufacturing (or re-processing) solvents is less intensive environmentally and economically than either creation of virgin solvents or the destruction of solvents, net benefits are achievable.



Online Resource: EPA has developed a mass-balance model tool for assessing how remanufacturing spent processing-aid solvents can benefit operations. The tool allows the user to put in the volume of spent solvent to calculate reductions in energy use; reduced air, water, and solid waste emissions; and enumerated cost savings associated with switching from disposal to remanufacturing. The tool can be obtained by contacting the Green Engineering Program at <http://www.epa.gov/opptintr/greenengineering/pubs/industry.html>.

P2: On the Path to Greener Chemistry

Example: Extending the Life of Solvents



Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: This slide illustrates the flow of materials and their purification. Starting with the raw materials of oil and natural gas, the materials are processed into a basic commercial-grade solvent, which can be further processing to specialty-grade and then pharmaceutical-grade.



Instructions: The boxes below each picture list the markets and users of these grades. The basic organic sector uses large volumes of Grade 3 (end market). Specialty and pharma use purified Grades 1 and 2 (middle and supply markets).



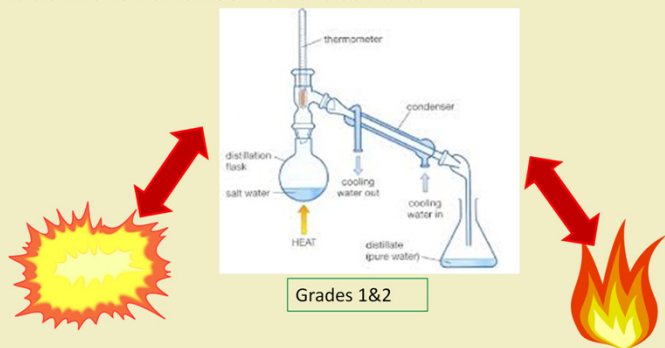
Say: Grade 3 is commercial grades with greater than 90% toluene, less than 5% xylene, and less than 3% benzene. Grade 3 is used in basic organic manufacturing in large volumes as an ingredient and also in the plastic and resin sector in benzene-based nonpolar chemical reaction chains.

Grade 1 is analytical-laboratory-grade, with greater than 99% toluene, and is benzene-free. It is used in the pharmaceutical sector. Grade 2 is academic-laboratory-grade, with greater than 95% toluene, and is also benzene-free. It is primarily used by the specialty chemical manufacturing sector.

P2: On the Path to Greener Chemistry

Current Scenario: Purify Grades 1 and 2

Use material once* and destruct



* Used as a reaction solvent: a chemical used to dissolve the ingredients in a batch reactor



Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator

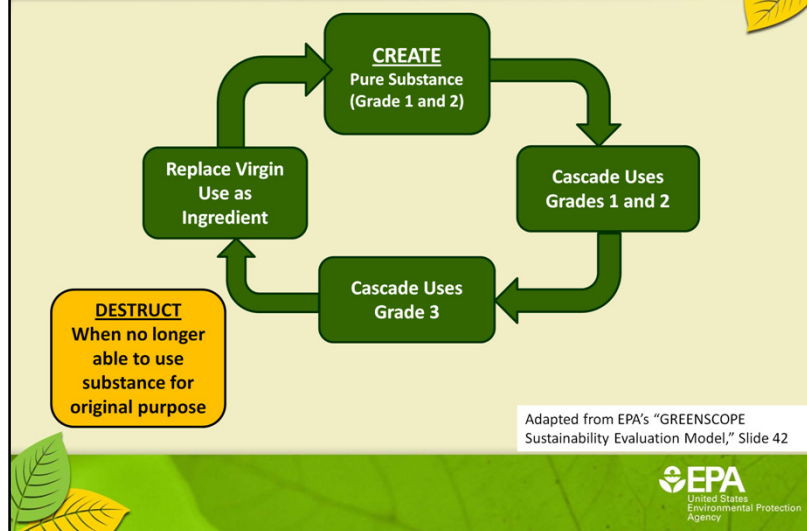


Say: This slide illustrates the current scenario for Grade 1 and 2 “reaction” solvents.

Energy and materials are expended (with environmental and economic impacts) to create the purified Grade 1 and 2. The “purified” grade is used once in pure processes. Energy and materials are also expended to destruct the purified grade 1 and 2.

P2: On the Path to Greener Chemistry

Perspective Change: Identify Markets/Opportunities



Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: This slide illustrates the life cycle and viable use opportunities at various stage or markets. "Create" and "destruct" have the largest E3 footprint (economy, energy, and environment). Avoided disposal and creation reaps the greatest benefits.

The illustration shows a cascade market that starts with greatest purity, Grade 1, and identifies uses cascaded from purity requirements for use—from pharmaceutical supply Grade 1 uses to grade 2 uses, then onto commercial-grade uses and use as an ingredient.

P2: On the Path to Greener Chemistry

Current Grade 1 (Pharmaceutical) Offsite Destruction Routes *Transport and Fuel Blending (High-Volume Grade 3 Users Also Shown)*



Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: This example shows disposal routes for methanol and toluene from a Grade 1 pharmaceutical facility in Elktion, Virginia. It shows:

- Materials transported long distances on a hazardous waste manifest to Ohio and/or South Carolina.
- Materials "fuel-blended" (blending of toluene and methanol).
- Fuel-blended materials destroyed in kiln.

An alternative/GEMM scenario is:

- Pharmaceutical Grade 1 materials transported on a bill of lading to a basic organic chemical manufacturer using Grade 3 as an ingredient.
- In the case of methanol, this would be an intrastate transport from Elktion to Hopewell, Virginia.
- The Grade 1 methanol is used to replace virgin Grade 3 methanol, and consumed at the Hopewell plant as an ingredient.

It also illustrates the use of TRI "waste" transfer analysis and the GEMM model in deriving viable scenarios and potential benefits.

P2: On the Path to Greener Chemistry

What Is Green Engineering?

- Green engineering is about designing, commercializing, and using feasible economical processes and products to reduce pollution at the source and minimize risk
 - GE designs and improves processes, unit operations, and material management practices
 - e.g., extends the life of chemical products
- Principles of green engineering integrate the fields of chemical engineering and risk assessment and include:
 - Design, retrofit, and optimize the use of feedstocks
 - Reduce or eliminate waste streams
 - Consider all unit operations in processes and products
 - Use of systems approaches that integrate environmental impact assessments
 - Use life-cycle thinking
 - Use engineering solutions that are cognizant of local geography and culture



Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: To this point, we have described an important role of green engineering in promoting remanufacturing and reuse of spent/used solvents, extending the useful life of a solvent, which promotes the preservation of natural resources and can also support energy and cost savings.



Key Point: However, green engineering is a much broader concept and more closely aligned with green chemistry.



Say: *Green chemistry* is the design of chemical products and processes to reduce or eliminate the use or generation of hazardous substances. Green chemistry includes feedstocks, reagents, catalysts, solvents, byproducts, synthesis, separations, reactions conditions, and formulations.

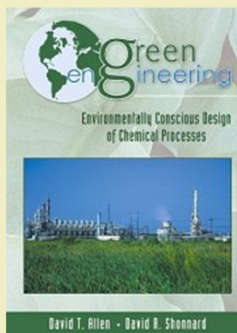
Green engineering is the design, commercialization, and use of industrial processes that are feasible and economical while minimizing risk to human health and the environment. Green engineering includes materials and energy balance, mass transfer, heat transfer, thermodynamics, reactor design, unit operations, materials selection, capital and operational costs, life cycle, and siting.

Chemists and engineers are designers who have the ability to affect molecules, materials, products, processes, and systems *at the earliest possible stages of their development*. The principles of green chemistry and green engineering provide a framework for scientists and engineers to use when designing new materials, products, processes, and systems.

P2: On the Path to Greener Chemistry

Green Engineering in EPA Region 5

- Illinois Institute of Technology
- Northwestern University
- Notre Dame University
- Michigan State University
- Michigan Tech University
- University of Minnesota—Minneapolis
- Ohio University—Athens
- University of Dayton
- University of Toledo
- Youngstown State University



Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: Who is practicing—or teaching—green engineering in Region 5? This slide lists schools currently engaged in green engineering.

One of EPA's Green Engineering Program goals was to introduce a "green" philosophy into chemical engineering programs, which would then spread Green Engineering principles to industrial and commercial manufacturing across the country. The first step was the development of a Green Engineering textbook, [*Green Engineering: Environmentally Conscious Design of Chemical Processes*](#). Textbook and class outline were designed in a modular format—allowing universities to incorporate the entire course as a technical elective, or incorporate chapters of the course into current chemical engineering curricula.

Note: With the development of the textbook, regional workshops were conducted to train educators across the country on green engineering and the use of the textbook. These training modules are available at <http://www.epa.gov/opptintr/greenengineering/pubs/educational.html#modules>.

P2: On the Path to Greener Chemistry

What Is Green Chemistry?

- Green chemistry is about designing chemical products and processes that reduce or eliminate the use or generation of hazardous substances
 - GC designs new chemical products and pathways
- Some principles of green chemistry include:
 - A focus on all types of chemicals (and their life cycle), e.g., greener products that are
 - Less toxic than current products
 - Inherently safer because they reduce the likelihood or severity of accidents
 - Recyclable or biodegradable after use
 - Safer for the atmosphere (e.g., do not deplete ozone or form smog)
 - Focus on all types of chemical activity, e.g., greener synthesis, reaction conditions, separations, analysis, and monitoring that
 - Use novel processing methods that prevent pollution at its source
 - Use greener feedstocks, reagents, and solvents (e.g., that are innocuous or renewable)
 - Eliminate energy-, material-, or water-intensive steps
 - Incorporate green chemistry at the earliest design stages of new chemical products and processes, but also
 - Make incremental improvements at any stage of a chemical's lifecycle or a chemical activity



Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: “Green chemistry” refers to the field of chemistry that deals with:

- Synthesis: the path to making chemicals.
- Processing: the actual making of chemicals, which is also closely related to green engineering.
- Use of chemicals that reduce risks to humans and impact on the environment.

The principles of green chemistry relate to the concept of “benign by design.” In Module 3 of this training, you will learn more about Design for the Environment and Alternatives Assessment tools such as GreenScreen, which adopt many of the green chemistry principles in their approaches, criteria, or benchmarks.

P2: On the Path to Greener Chemistry

Market-Based Opportunities for P2

- Green chemistry is a key value proposition for business and regional economic development
- There are a remarkable number of programs across federal, state, and local government agencies poised to support green chemistry and business development
- Green chemistry training for TAPs serves as a critical venue for:
 - Stimulating interest in competitive P2 grants for green chemistry innovative research by public research institutions, in partnership with private organizations
 - Providing advanced supply chain opportunities for reducing generation, use, and disposal of hazardous materials
 - Supporting small business innovation
 - Widespread adoption of recognized technologies

Office of Pollution Prevention and Toxics
EPA
United States Environmental Protection Agency

Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: Customized EPA-region-based training provides opportunities for local assistance providers to meet geographical and economic needs. This is a pilot project, initiated in collaboration with the Chicago-based EPA Region 5 team, that we hope will continue to develop in collaboration with Pollution Prevention Coordinators across the country to better understand the training needs within their states and local communities.

We also aim to bring a broader understanding of green chemistry, green engineering, Design for Environment, and other P2 benefits, resources, and available technology solutions. Some of these we hope to share with you today; hopefully, we will provide you with new knowledge and tools to use in working with your local businesses and communities—not just ways to help find environmental solutions but also ways to promote technology innovations by local companies.

P2: On the Path to Greener Chemistry

Green Chemistry: Sources of Value Propositions *Improving Economic and Environmental Performance*

Cost Savings (Materials and Energy)

- Energy savings
- Water savings
- Natural resources (synthesis and processing efficiencies)
- Pollution prevention (hazardous materials generation and waste handling)

New Products (Sources of Revenue)

- Sustainable/sustainability products
- Enhanced performance characteristics

Managing/Transforming Waste

- Liability -> asset



Office of Pollution Prevention and Toxics
EPA
United States Environmental Protection Agency

Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: The products of chemistry are present in nearly every facet of the economy. Chemistry makes billion-dollar contributions to economies worldwide.

Hundreds of thousands of jobs depend on the upstream chemical industry, while millions of jobs depend on chemistry research in areas such as textiles, aerospace, automotive, and health care.

The chemical industry requires considerable supply chains, creating many more jobs in the process. Chemistry is crucial in enabling virtually every other industry to operate.



Background Information: This information is adapted from “Chemistry Boosts to GDP”: <http://www.soci.org/Chemistry-and-Industry/Cnl-Data/2010/19/Chemistry-boost-to-GDP>.



Say: Benign, safer “green chemistry” is the foundation of safer products and practices that are truly protective of worker and consumer health and the environment—and of sustainability, meeting the needs of the present generation without compromising the needs of future generations.

P2: On the Path to Greener Chemistry

Presidential Green Chemistry Challenge

Annual awards to recognize the most innovative green chemistry technologies and to document quantified benefits

- 2012 awards marked the 17th year
- 88 winners from 1,492 nominations

Into the Future

- Shifting emphasis to expanding upon innovations of nominees
- Amplifying innovation by leveraging technology/manufacturing initiatives at the federal/state/local level, and through private sector interests
- EPA is working actively to help partner green chemistry innovators with supply chain opportunities, leveraging existing assistance programs

Office of Pollution Prevention and Toxics
EPA
United States Environmental Protection Agency

Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: The Presidential Green Chemistry Challenge Awards promote the environmental and economic benefits of developing and using novel green chemistry. These prestigious annual awards recognize chemical technologies that incorporate the principles of green chemistry into chemical design, manufacture, and use.

EPA's Office of Chemical Safety and Pollution Prevention sponsors the Presidential Green Chemistry Challenge Awards in partnership with the American Chemical Society Green Chemistry Institute® and other members of the chemical community including industry, trade associations, academic institutions, and other government agencies.

Through 2012, our 88 winning technologies have made billions of pounds of progress, including:

- 825 million pounds of hazardous chemicals and solvents eliminated each year—enough to fill almost 3,800 railroad tank cars or a train nearly 47 miles long.
- 21 billion gallons of water saved each year—the amount of water used by 820,000 people annually.
- 7.9 billion pounds of carbon dioxide equivalent released to air eliminated each year—equal to taking 810,000 automobiles off the road.

P2: On the Path to Greener Chemistry

Green Chemistry Awards

Presidential Green Chemistry Challenge Award Recipients by Industry Sector

On this page:
Index of Presidential Green Chemistry Challenge Award winners by industry sector.

On other pages:
• [Winning Technologies Indexed by year](#)
• [Winning Technologies Indexed by technology](#)

DISCLAIMER: The short descriptions provided in this section were derived by EPA from the winning entries received for the Presidential Green Chemistry Challenge Awards and other public information. They are not officially endorsed by EPA, nor does EPA endorse any of the products mentioned in them. Claims made in these descriptions have not been verified by EPA. Each description represents only one aspect of the information in an entry and, as such, is intended merely to point users of this Web site to a summary of the winning entry.

Select an Industry Sector:
Industry Subtopics

Agriculture and Agrochemicals: such as fertilizers, plant growth stimulators. 5 technologies
See also: [Fertilizers](#)
See also: [Renewable Resources](#)

Year	Winner	Description of the Winning Technology in Relation to the Topic Area
2004	Jensell Biosurfactant Company	Rhemolipid biosurfactant: a bio-based, biodegradable surfactant to increase penetration and dispersion of agricultural chemicals in soil and foliage; also an active biodegradable summary
2001	Bayer Corporation; Bayer AG (technology acquired by LANXESS)	BayerCrop™ CX imidazopyridine: a biodegradable chelating agent that prevents, corrects, and minimizes mineral deficiencies in crops summary
2001	EDEN Bioscience Corporation	Messenger proteins: nontoxic, naturally occurring harpin proteins produced by fermentation, stimulate plant growth and defenses against disease and pests summary

Industry Subtopics:
Agriculture and Agrochemicals
Pesticides
Automotive and Transportation
Broad Applicability
Buildings and Architecture
Bulk and Commodity Chemicals
Electronics and Semiconductors
Food
Formulation Ingredients
Formulated Products
Fuels
Medical Devices
Paints and Coatings
Pharmaceuticals
Pigments, Dyes, and Colorants
Plastics
Printing and Imaging
Pulp and Paper
Safety
Soaps and Detergents
Textiles and Fibers
Water Treatment
Industry Subtopics

EPA
United States
Environmental Protection
Agency

Subtopic

Defining green chemistry and green engineering
20 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Articulate the difference between green chemistry and green engineering

Notes for the Facilitator



Say: The new “One EPA” green chemistry website, developed in collaboration with EPA program and regional offices, allows users to search for award-winning technologies by sector, by technology, and by year. Also available is a broader set of nominated technologies. <http://www2.epa.gov/green-chemistry>

Online Resources:

The **Michigan Green Chemistry Clearinghouse** hosts webinars and is an interactive site providing information, data, learning opportunities, and interactive tools. <http://migreenchemistry.org/>

The **Minnesota Green Chemistry Forum** fosters a common understanding among businesses, government, non-governmental organizations (NGOs), and academia to advance green chemistry practice and policy in Minnesota and nationally. <http://www.greenchemistrymn.org/>

Indiana Partners for Pollution Prevention is composed of Indiana industries, businesses, nonprofit organizations, and governmental entities that are interested in P2 and the financial and environmental benefits of P2 projects. <http://www.in.gov/idem/ppp/>

The **Solid and Hazardous Waste Education Center** strives to enhance Wisconsin’s environment and economy by providing quality education, information, and technical assistance. <http://fyi.uwex.edu/shwec/category/toxicgreen-chemistry/>

The **Ohio Sustainable Business Council** believes that sustainable economic development is compatible with shared prosperity, environmental protection, and social justice. <http://www.osbcouncil.com/>

The **Great Lakes Green Chemistry Network** is a partnership that promotes green chemistry practice, outreach, and education in the binational Great Lakes region. <http://glgc.drupalgardens.com/>

The **Great Lakes Pollution Prevention Roundtable** promotes information exchange and networking to P2 professionals in the Great Lakes regions of the United States and Canada. <http://www.glrppr.org/>

The **2014 Great Lakes Green Chemistry Conference** ran from March 31 to April 3, 2014 in Wyndham Cleveland, Cleveland, Ohio. <http://www.glrppr.org/conference2013/index-3.html>

P2: On the Path to Greener Chemistry

National P2 Metrics

History of Grant Metrics

- Measuring multi-media hazardous reductions and related economic savings relates to P2 Act source reduction
- Measuring energy and water savings relates to the P2 Policy Statement and Executive Orders
- Energy savings metric was changed to greenhouse gas emissions in 2010
- EPA coordinates with National Pollution Prevention Roundtable P2 Results Task Force



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Say: In coordination with the NPPR P2 Results Task Force, EPA reports 10% of non-grant state P2 results to account for EPA's extended sphere of influence in supporting state P2 programs through P2Rx and other means.



Online Resource: Great Lakes Regional Measurement Task Force:
http://www.glrppr.org/aboutus/regional_measurements.cfm.

P2: On the Path to Greener Chemistry

National P2 Metrics

Collecting Metrics Today

Measures are:

1. Pounds of hazardous materials/emissions reduced
2. Million metric tons of carbon dioxide equivalent avoided
3. Gallons of water saved
4. Dollars that are saved from results produced under the first three measures
 - Details on how to appropriately collect metrics are current in the EPA Regional P2 Measurement Guidance.
 - EPA applies formulas to account for results that last more than a year (recurring results).



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Say: EPA manages a variety of environmental stewardship programs that encourage companies to reduce and prevent pollution. EPA uses a suite of measures or “metrics” to evaluate the effectiveness of its P2 programs. A major reason that EPA measures P2 outcomes is to fulfill requirements of its strategic plan.

EPA’s P2 programs are perhaps its best-recognized efforts. A report from the Science Advisory Board to EPA’s Administrator stated that, “the P2 programs are among the most forward-looking and important programs of the EPA, defining a new model for environmental protection and restoration based on voluntary initiative that is prompted by incentives for cost savings and higher product and process performance. These are also among the most difficult programs to implement, as they are based on voluntary participation by partner organizations, the appropriate data to assess the individual programs are not readily available, the information can be sensitive as it may provide a competitive advantage to competing organizations, and effective approaches are often specific to the particular product or process. Measuring progress achieved at the program level is challenging because, for a variety of good reasons, results are measured in different ways, and on different time scales.”



Online Resource: The full report is available at

[http://yosemite.epa.gov/sab/sabproduct.nsf/36a1ca3f683ae57a85256ce9006a32d0/F6A39F03493E4EA38525750C0074E448/\\$File/EPA-SAB-09-005-unsigned.pdf](http://yosemite.epa.gov/sab/sabproduct.nsf/36a1ca3f683ae57a85256ce9006a32d0/F6A39F03493E4EA38525750C0074E448/$File/EPA-SAB-09-005-unsigned.pdf).

P2: On the Path to Greener Chemistry

National P2 Metrics

Metric #1: Hazardous Pounds

- “Hazardous” means hazardous, toxic, any chemical of regulation or concern (except greenhouse gases, metric #3) at national or state level
- “Hazardous” excludes non-hazardous (paper, plastic, metal, wood, and so on)
- “Pounds” includes air emissions, water emissions, hazardous waste, and hazardous production inputs
- Excludes post-discard recycling, but not direct reuse and pre-discard remanufacturing
- EPA has a gallon-to-pound converter for putting liquid hazardous wastes into pounds



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Say: EPA’s P2 Strategic Plan for 2010 through 2014 includes a goal to reduce the manufacture and use of hazardous materials to improve human and ecological health. Measuring the pounds of hazardous waste reduced is essential to meeting this goal.



Background Information: Strategies to achieve this goal include:

- Encouraging life cycle reduction of hazardous materials through redesign.
- Encouraging and providing support for the design of products and systems that minimize the use of hazardous materials throughout the life cycle.
- Facilitating information-sharing on hazardous materials of concern and providing technical expertise and support for green chemistry, green engineering, and Design for the Environment Alternatives Assessment and recognition efforts.
- Offering guidance on the reduction of hazardous materials.
- Supporting P2 assistance providers in giving guidance to businesses, governments, and consumers on the reduction of hazardous materials and informed chemicals substitution.



Online Resource: P2 Measurement and Tools, available at
<http://www.epa.gov/p2/pubs/resources/measurement.html>.

P2: On the Path to Greener Chemistry

National P2 Metrics

Metric # 2: Dollars Saved

- Dollars saved from pollution prevention activities
 - This measure counts cost savings associated with the following results achieved from P2 activities: hazardous materials and hazardous emissions reduced, GHG emissions reduced, and water saved
 - EPA's P2 Cost Savings Calculator is available on EPA's P2 Web page (click on "Measurement").
 - The tool converts hazardous materials and hazardous emissions reduced, GHG emissions reduced, and water savings into dollars saved.
 - EPA provides a P2 Cost Savings Calculator on the measurement page at www.epa.gov/p2



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Say: The P2 Cost Calculator helps convert results from metrics 1, 3, and 4 into dollars saved. It assesses cost savings associated with reduced costs for hazardous inputs in a facility process, reduced costs for handling hazardous waste, reductions in annual air permitting fees that are based on actual emissions, reduced water discharge treatment costs based on gallons discharged, reduced charges for water usage, reduced fuel costs, and reduced costs for electricity. Understanding potential cost savings presents a big incentive for action and collaboration to program beneficiaries.



Online Resource: EPA provides a P2 Cost Savings Calculator on the measurement page of the P2 website at www.epa.gov/p2.

P2: On the Path to Greener Chemistry

National P2 Metrics

Metric #3: Greenhouse Gas Emissions Reduced

- GHG measure: million metric tons of carbon dioxide equivalent (MMTCO₂e)
 - EPA provides a P2 Greenhouse Gas Calculator on the measurement page at www.epa.gov/p2



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Say: EPA's P2 GHG Calculator converts GHG emission reductions from electricity conservation, green energy, fuel and chemical substitutions with lower GHG-intensities, water conservation, and improved materials and process management in the chemical manufacturing sector. This tool will help program participants submit higher-quality data for the program measure, and demonstrates the unique multi-media perspective that P2 brings to reduce metric tons of carbon dioxide equivalent (MTCO₂e).



Online Resource: EPA provides a P2 Greenhouse Gas Calculator on the measurement page of the P2 website at www.epa.gov/p2.



Background Information: Grantees report GHG emissions in MTCO₂e.

P2: On the Path to Greener Chemistry

National P2 Metrics

Metric #4: Gallons of Water Saved

- Focuses on water saved/conserved from P2 activities
 - If a million gallons of water effluent are avoided, that would be a million gallons of water saved and 10 pounds of hazardous pounds reduced



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Say: If a million gallons of water effluent are avoided, that would be a millions gallons of water saved and 10 pounds of hazardous pounds reduced. EPA's estimated approach to discounting the volume of water is to divide the volume of water effluent by 100,000.

P2: On the Path to Greener Chemistry

GHG Calculator: Greening Chemistry Tab

The “Greening Chemistry” tab of the Greenhouse Gas Calculator addresses the global warming potential (GWP) of various chemicals, and provides for determining the benefits of chemical substitutions

- The calculator is on the measurement page of the P2 website at www.epa.gov/p2



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Say: The green chemistry tab of the GHG Calculator addresses the global warming potential (GWP) of various chemicals, and provides for determining the benefits of chemical substitutions. It calculates GHG reductions from:

1. Using less high-GWP chemicals.
2. Switching to chemicals with little to no global warming impact.

The green chemistry tab also gives CO₂ equivalency of 95 chemicals from the Intergovernmental Panel on Climate Change: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆), plus ones from EPA’s GHG Reporting Program.

It’s worth noting that GHG reduction from chemical substitution is one aspect or measure of greener production, but it isn’t necessarily green chemistry. It can be green engineering.

The subsequent slides show a screenshot of the tab, an explanation of the tab, and an illustrative example of a hazard substitution using the tab.



Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

66
99

Say: This slide presents a screen shot of the green chemistry tab on the P2 Greenhouse Gas Calculator. The calculator is on the measurement page of the P2 website at www.epa.gov/p2.

P2: On the Path to Greener Chemistry



APPENDIX A: MODULE 1 RESOURCE COMPENDIUM

Tools for Alternatives and Substitutions

1. ChemView is an EPA Web-based tool created to improve chemical safety and provide more streamlined access to information on chemicals. The database greatly improves access to health and safety data on chemicals regulated under the Toxic Substances Control Act (TSCA). It contains information EPA receives and develops about chemicals, including those on EPA's Safer Chemical Ingredient List. The goal of the database is to allow the public easy access to information on chemicals in order to make safe and more informed decisions about the chemicals they use.
<http://www.epa.gov/chemview/>

Resources for Green Chemistry Challenge Awards

1. EPA Presidential Green Chemistry Challenge Awards promote the environmental and economic benefits of developing and using novel green chemistry. These prestigious annual awards recognize chemical technologies that incorporate the principles of green chemistry into chemical design, manufacture, and use. <http://www2.epa.gov/green-chemistry/information-about-presidential-green-chemistry-challenge>
2. Searchable database of the Presidential Green Chemistry Challenge Award winners: <http://www2.epa.gov/green-chemistry/presidential-green-chemistry-challenge-winners>
3. EPA efforts in the area of sustainability practices and approaches include labeling green products and promoting green chemistry and engineering, managing materials rather than creating waste, using green infrastructure to manage storm water runoff, and supporting the sustainable design of communities. <http://www.epa.gov/sustainability/>
4. GoodGuide provides the world's largest and most reliable source of information on health, environmental, and social impacts of consumer products. <http://www.goodguide.com/>
5. "Green" Alternatives Wizard: <http://ehs.mit.edu/site/content/green-chemical-alternatives-purchasing-wizard>
6. NSF/GCI/ANSI 355 ("Greener Chemicals and Processes Information Standard") is the only standard available with which to document information on sustainability-related attributes of chemical products and processes, thus allowing manufacturers and formulators to easily compare the hazards and process impacts of chemical products. http://www.nsf.org/business/sustainability/product_greener_chemicals.asp?program=Sustainability
7. SUBSPORT Substitution Support Portal project is an Internet portal that constitutes a state-of-the-art resource on safer alternatives to the use of hazardous chemicals. This site also provides information on tools and guidance for substance evaluation and substitution management. <http://www.subsport.eu/about-the-project>
8. Sustainable Purchasing Council: <http://www.purchasingcouncil.org/about/>

P2: On the Path to Greener Chemistry

Greening Chemistry Tab

- Calculates GHG reductions from a) using less high-GWP chemicals and b) switching to chemicals with little to no global warming impact
 - Gives CO₂ equivalency of 95 chemicals from Intergovernmental Panel on Climate Change: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF₆), plus ones from EPA's GHG Reporting Program
 - Enter mass of each chemical avoided for a project in "lbs. chemical avoided" column
 - Total lbs CO₂e avoided and MTCO₂e reduced will be displayed for each project in rows "ALL CHEMICALS"



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Discussion Questions:

1. When quantifying the success of your green chemistry projects (such as pounds of hazardous substances reduced), can you identify other existing tools that would capture resulting GHG reductions?
2. In addition to capturing hazardous substances reduced as a result of applying green chemistry concepts, should EPA be capturing other related metrics?

P2: On the Path to Greener Chemistry

Greening Chemistry Tab—Example

- ABC Company improved leak detection in their use of sulfur hexafluoride in their electrical distribution equipment
- ABC saved 600 pounds of SF₆ for the year (input 600 pounds into cell I47; see output of 14,340,000 pounds of CO₂ in cell I12 and 6,504 MTCO₂e in cell I10)



Subtopic

National P2 metrics and calculators for measuring success
15 minutes
(Elapsed time: 45 minutes)

Specific Outcomes

Increased use of P2 Calculator to calculate GHG reductions related to certain chemical substitutions

Notes for the Facilitator



Online Resource: This slide presents a screenshot of green chemistry tab on the P2 Greenhouse Gas Calculator. The calculator is on the measurement page of the P2 website at www.epa.gov/p2.



Instructions: To work through an example:

1. Enter the mass of each chemical avoided for a project in the “lbs. chemical avoided” column. Total pounds CO₂e avoided and MTCO₂e reduced will be displayed for each project in the “ALL CHEMICALS” rows.
2. Input 600 pounds into cell I47 and see an output of 14,340,000 pounds of CO₂ in cell I12 and 6,504 MTCO₂e in cell I10.
3. ABC Company improved leak detection in their use of sulfur hexafluoride in their electrical distribution equipment. ABC saved 600 pounds of SF₆ for the year.

P2: On the Path to Greener Chemistry



APPENDIX A: MODULE 1 RESOURCE COMPENDIUM

Tools for Chemical Assessments

1. ACS GCI Pharmaceutical Roundtable Solvent Selection Guide, Version 2.0, issued March 21, 2011: <http://surveys.acs.org/se.ashx?s=04BD76CC0E5496A7>
2. CDC Agency for Toxic Substances and Disease Registry (ATSDR) portal: access the most important information about toxic substances and how they affect human health. <http://www.atsdr.cdc.gov/substances/index.asp>
3. ChemSpider is a free chemical structure database providing fast text and structure search access to over 28 million structures from hundreds of data sources. <http://www.chemspider.com/>
4. California Proposition 65, the Safe Drinking Water and Toxic Enforcement Act of 1986, was enacted as a ballot initiative in November 1986. The Proposition was intended by its authors to protect California citizens and the state's drinking water sources from chemicals known to cause cancer, birth defects, or other reproductive harm, and to inform citizens about exposures to such chemicals. Proposition 65 requires the Governor to publish, at least annually, a list of chemicals known to the state to cause cancer or reproductive toxicity. http://oehha.ca.gov/prop65/prop65_list/Newlist.html
5. EPA Discussion on Identifying Priority Chemicals for Review and Assessment: Identification of a chemical as a priority chemical would indicate only that the Agency intends to review it on a priority basis, not that it poses a risk. <http://www.epa.gov/oppt/existingchemicals/pubs/chempridiscguide.html#review>
6. EPA's P2 program provides tools for reducing or eliminating waste at the source. <http://www.epa.gov/p2/tools/p2tools.htm>
7. EPA's Sustainable Futures Initiative has the goal to make new chemicals safer, available faster, and at lower cost. It works by giving chemical developers the same risk-screening models that EPA uses to evaluate new chemicals before they enter the market. <http://www.epa.gov/oppt/sf/>
8. EPA's Toxicity Estimation Software Tool (TEST) enables users to easily estimate acute toxicity using quantitative structure activity relationship methodologies. <http://www.epa.gov/nrmrl/std/qsar/qsar.html>
9. EPA's Toxics Release Inventory Program (TRI) tracks the management of certain toxic chemicals that may pose a threat to human health and the environment. U.S. facilities in different industry sectors must report annually how much of each chemical is released to the environment and/or managed through recycling, energy recovery and treatment. <http://www2.epa.gov/toxics-release-inventory-tri-program>
10. Risk-Screening Environmental Indicators (RSEI) is a computer-based screening tool developed by EPA that analyzes risk factors to put TRI release data into a chronic health context. <http://www.epa.gov/opptintr/rsei/>
11. The TRI Pollution Prevention Search allows you to view pollution prevention activities and associated reductions in toxic chemical release quantities. <http://www.epa.gov/enviro/facts/tri/p2.html>

P2: On the Path to Greener Chemistry



APPENDIX A: MODULE 1 RESOURCE COMPENDIUM

Tools for Chemical Assessments

12. NSF/GCI/ANSI 355 ("Greener Chemicals and Processes Information Standard") is the only standard available with which to document information on sustainability-related attributes of chemical products and processes, thus allowing manufacturers and formulators to easily compare the hazards and process impacts of chemical products.
http://www.nsf.org/business/sustainability/product_greener_chemicals.asp?program=Sustainability
13. OSHA's Occupational Chemical Database is a reference for the occupational safety and health community, developed in cooperation with EPA.
<http://www.osha.gov/chemicaldata/>

Tools for Alternatives and Substitutions

1. CleanGredients, a project of GreenBlue®, is an online database of cleaning product ingredient chemicals, providing verified information about the environmental and human health attributes of listed ingredients. <http://www.cleangredients.org/home>
2. EPA's Design for the Environment (DfE) Alternatives Assessments characterize chemical hazards based on a range of health and environmental information. Chemical choices made based on these assessments can minimize the potential for moving from a potentially problematic chemical to a poorly understood alternative.
http://www.epa.gov/dfe/alternative_assessments.html
3. EPA's DfE Safer Product Labeling Program.
<http://www.epa.gov/dfe/pubs/projects/formulat/formpart.htm>
4. EPA's DfE Safer Chemical Ingredients List contains chemicals that meet the criteria of the DfE Safer Product Labeling Program. This list of safer chemical ingredients is arranged by functional-use class and will assist product manufacturers in identifying chemicals that the DfE program has evaluated and identified as safer.
<http://www.epa.gov/dfe/saferingredients.htm>
5. EPA's Green Engineering Program promotes the design, commercialization, and use of processes and products that are feasible and economical while reducing the generation of pollution at the source and minimizing the risk to human health and the environment.
<http://www.epa.gov/oppt/greenengineering/>
6. EPA PARIS II: Computer Aided Solvent Design for Pollution Prevention: Industrial solvents whose continued use raises concern for worker health and toxics in the environment need to be replaced cost-effectively. This software tool identifies pure chemicals or designs chemical mixtures that can serve as alternatives to more hazardous substances currently in use. <http://www.epa.gov/nrmrl/std/paris/paris.htm>

P2: On the Path to Greener Chemistry



APPENDIX A: MODULE 1 RESOURCE COMPENDIUM

Resources for Green Chemistry Education

1. ACS Green Chemistry Institute:
http://portal.acs.org/portal/acs/corg/content?nfpb=true&pageLabel=PP_TRANSITIONMAIN&node_id=1400&use_sec=false&sec_url_var=region1&uuid=
2. Green Chemistry at Hendrix: <http://www.hendrix.edu/greenchemistry/>
3. Green Chemistry Network (UK): <http://www.greenchemistrynetwork.org/>
4. Greener Education Materials for Chemists:
<http://greenchem.uoregon.edu/Pages/Overview.php?CategoryIDString=Preview-2-7&FullTextSearchKeywords=Clean&CategoriesToSearch=Minimize+the+Potential+for+Accidents&NumberOfMainCategories=7&AnyAll=Any&ID=64>
5. Greening Across the Chemistry Curriculum at University of Scranton:
<http://academic.scranton.edu/faculty/cannm1/dreyfusmodules.html>
6. Next Generation Environmental Technologies book:
http://www.rand.org/pubs/monograph_reports/MR1682.html
7. The University of York (UK) Green Chemistry Centre of Excellence:
<http://www.york.ac.uk/chemistry/research/green/>

Calculators

1. Buildings Industry Transportation and Electricity Scenarios (BITES): This tool lets users explore the energy and carbon implications of altering the current U.S. energy profile. It is not an energy economic model does not estimate scenario costs or savings.
<https://bites.nrel.gov/index.php>
2. Greenhouse Gas Calculator: This tool converts standard metrics for electricity, green energy, fuel use, chemical use, water use, and materials management into metric tons of carbon dioxide equivalent, MTCO₂e, using standard national conversion factors.
<http://www.epa.gov/p2/pubs/resources/measurement.html#calc>
3. Gallons to Pounds Converter: Converts gallons of hazardous materials to pounds.
<http://www.epa.gov/p2/pubs/resources/measurement.html#calc>
4. Product Mass Intensity Calculator: Product mass intensity is the ratio of the quantity of raw materials used to the quantity of product produced. Calculating this helps to track the environmental footprint and the efficiency of the manufacturing process.
http://portal.acs.org/portal/PublicWebSite/greenchemistry/industriainnovation/roundtable/CNBP_026644
5. St. Olaf College's Green Chemistry Assistant analyzes chemical processes to calculate atom economy, percent excess, and theoretical yield. <http://fusion.stolaf.edu/gca/>